LABORATORIES INC.

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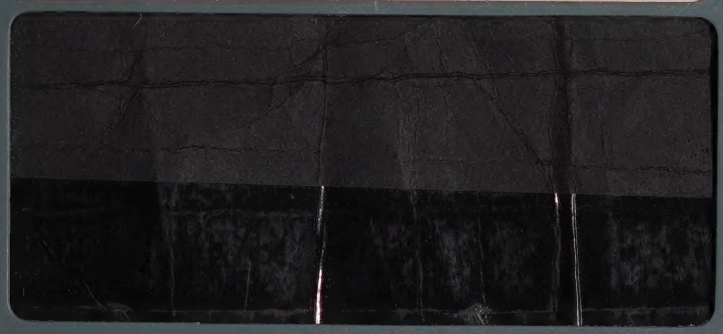
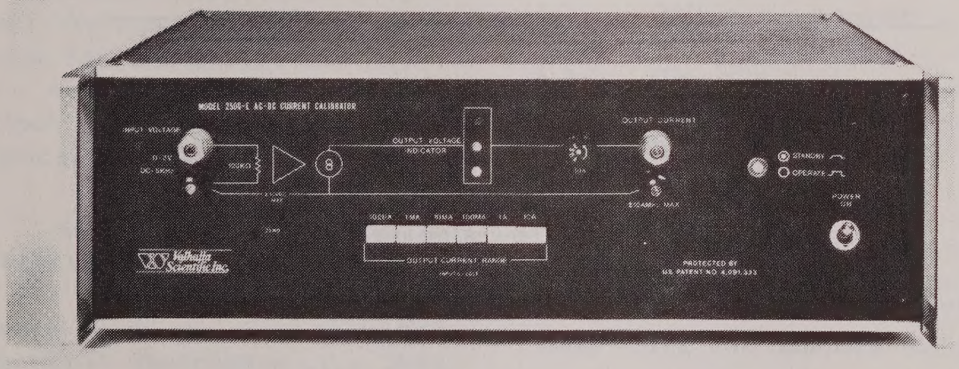


VALHALLA SCIENTIFIC

2500E/EP

AC-DC Current Calibrators

Operating and Maintenance Manual



CERTIFICATION

Valhalla Scientific Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. Valhalla Scientific Inc. further certifies that its calibration measurements are traceable to the National Bureau of Standards to the extent allowed by NBS's calibration facility.

WARRANTY

Vallhalla Scientific, Inc. warrants this instrument against defects in material and workmanship for one year from date of shipment. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific Inc. No other warranty is expressed or implied. We are not liable for consequential damages. Permission must be obtained directly from the factory for warranty repair returns. No liability will be accepted if returned without such permission.

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2500E/EP/EN

SPECIFICATIONS

RANGE:	100 uA 1mA 10mA 100mA 1A 10A
RESOLUTION:	1nA 10nA 100nA 1uA 10uA 100uA
DYNAMIC RANGE:	0 to 200% of range, DC or RMS AC, up to maximum rated output(DC to 100Hz)
FULLSCALE:	Fullscale = 200% of range
DC ACCURACY:	(180 days 25°C ±5°C) ±0.02% of fullscale ±0.01% of output
AC ACCURACY:	(180 days 25°C ±5°C) ±.05% of fullscale ±.05% of output to 5 KHz for 2500-E and 2500-EP; to 500 Hz for 2500-EN. [For compliance voltages greater than 2 volts, add 0.01% of range x compliance voltage x frequency (KHz). For 2500-EP on 100 uA range, add 0.5% above 1KHz]
INPUT IMPEDANCE:	100 Kilohms - 2500-E, 2500-EP 10 Megohms - 2500-EN
OUTPUT CAPACITANCE:	500 pico farads
COMPLIANCE VOLTAGE:	10 VDC or Peak AC, 7 VDC or Peak AC on 10 ampere range
INPUT/OUTPUT RATIO:	2.0000 volts input produces fullscale output, 20 volts for Model 2500-EN
MAXIMUM OUTPUT CURRENT:	12 amperes DC or RMS AC
MAXIMUM INPUT VOLTAGE:	3 volts DC or Peak AC, 30 volts DC or RMS AC for 2500-EN
OUTPUT PROTECTION:	Fuse protected at 15 amperes
INPUT COMMON MODE REJECTION RATIO:	60 db at DC, linearity increasing 40 dB at maximum frequency
TEMPERATURE RANGE:	0°C to 50°C
TEMPERATURE COEFFICIENT:	1/10 of accuracy specification per °C
HUMIDITY:	70% Relative Humidity at 45°C, noncondensing
SIZE:	381 mm/15"L x 432mm/17"W x 133mm/5.25"H
WEIGHT:	14 Kg/30 lbs. net, 18 Kg/40 lbs. shipping

VALHALLA SCIENTIFIC

SECTION I — GENERAL INFORMATION

1.1 DESCRIPTION

The Model 2500-E and Model 2500-EP AC-DC Current Calibrators are complete wide-range voltage-to-current converters. These instruments convert a precision input voltage to a proportional output current. The full scale current ranges are selectable in decade increments from 100 microamperes full scale to 10 amperes full scale. The Model 2500-E range selection is by means of a six-station push button switch mounted on the front panel. The Model 2500-EP range selection is remotely programmable through a rear panel connector. Both units are housed in a heavy-duty aluminum case which is ideally suited to the most rugged requirements.

1.2 ACCESSORIES

The Model 2500-E is shipped from the factory with a detachable power cord and an instruction manual. The Model 2500-EP is shipped with a power cord, instruction manual and a mating plug for the rear panel mounted range selector program input receptacle.

1.3 RACKMOUNT - OPTION R

The Model 2500-E and Model 2500-EP may be purchased with an Option R rackmount adaptor that fits a standard 19-inch equipment enclosure.

1.4 CABLE - OPTION C

The Option C Input Cable set may be purchased with the Models 2500-E and 2500-EP or may be obtained on separate order.

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SECTION II — INSTALLATION

2.1 INTRODUCTION

This section contains information for the inspection and installation of the Model 2500-E and Model 2500-EP AC-DC Current Calibrators.

2.2 INITIAL INSPECTION

If the external shipping container shows evidence of in-transit damage, such damage should be immediately brought to the attention of the carrier and such damage noted on the bill of lading.

Unpack the instrument and retain the shipping container until the instrument has been inspected for possible damage in shipment. If in-shipment damage is observed, notify the carrier and obtain his authorization for repairs before returning the instrument to the factory. Where the external shipping container shows evidence of damage in-transit, but the instrument shown no external damage, it may be advisable to perform the calibration procedure of Section V to determine that the instrument has not incurred hidden damage.

2.3 POWER REQUIREMENTS

The Model 2500-E and Model 2500-EP AC-DC Current Calibrators are normally shipped from the factory for operation from 105 to 125 volts AC at 60 Hz. The current requirement is 5 amperes.

NOTE

A rear panel mounted slide switch allows selection of 110 or 240 volt nominal line voltages.

2.4 INSTALLATION

If the Model 2500-E AC-DC Current Calibrator is to be used in a bench-top application, installation requires only that the power cord be inserted in the mating connector on the rear panel of the instrument and the other end of the cord be inserted into the wall receptacle. The Model 2500-EP will require, in addition, connection of the rear panel mounted range programming input connector to a suitable source of control signals. Information for connections to the remote programming source is provided in paragraph 2.5.

The Models 2500-E and 2500-EP use wind tunnel type heatsinks. Air is forced through the heatsink radiators by an internally mounted fan. Restriction of the air flow through the heatsink will result in excessive heating and possible failure of the power transistors. Caution should be taken to insure that neither the air inlet or air outlet is obstructed in any way. In rack mounted applications, the maximum ambient temperature within the rack should not exceed 50 degrees Celsius. If total power dissipation of equipment in the rack causes the ambient temperatures to exceed that limit, forced air cooling of the entire rack should be employed.

CAUTION

Do not restrict the airflow of the unit cooling system. Maintain the internal temperature of equipment racks at or below 50 degrees Celsius.

2.5 MODEL 2500-EP REMOTE PROGRAMMING

The Model 2500-EP has provisions for remote control of range selection and indi-

cation of output voltage range. Range selection requires an external 5-volt DC source. The 5-volt source negative is connected to pin 7 of J6 on the rear panel of the unit. The 5-volt source positive is then connected to one of the pins of J6, in accordance with the information listed in Table 2-1, to select the desired range. Only one pin is to be connected to the source positive at any time. These connections power relay coils with a current requirement of 30 milliamperes. Surge limiting diodes are internally connected across the coil of each relay. External surge limiting devices, therefore, are not required.

In addition to the output voltage range indicators provided on the front panel, internal relay contacts provide for connection of remote output voltage indicators. The relay contacts are connected to pins of J6, as listed in Table 2-1. They are not connected to any internal voltage source nor is surge limiting provided. Therefore, a voltage source must be provided external to the Model 2500-EP to power the remote indicators. If inductive devices are connected to these relay contacts, surge limiting must be provided.

Table 2-1. Model 2500-EP Remote Range Selection Programming Connections.

J6 Pin No.	Function
1	Selects 10 Ampere Range
2	Selects 1 Ampere Range
3	Selects 100 Milliampere Range
4	Selects 10 Milliampere Range
5	Selects 1 Milliampere Range
6	Selects 100 Microampere Range
7	5-Volt Source Negative Connection
8	N/C
9	Range Indicator Relay Contacts Common
10	Green Output Voltage Range Relay Contact
11	Orange Output Voltage Range Relay Contact
12	Red Output Voltage Range Relay Contact

SECTION III — OPERATION

3.1 INTRODUCTION

This section of the manual contains complete operating instructions for the Model 2500-E and 2500-EP AC-DC Current Calibrators.

3.2 INPUT VOLTAGE

The polarity and level of the output current of the Models 2500-E and 2500-EP is directly proportional to the input voltage polarity and level. A zero input voltage will produce a zero output current. As the input voltage is increased, the output current will increase within the selected range. With the 1 MA range selected, an input of 1.0000 volts DC will produce an output current of 1.0000 milliampere. If the input voltage is increased to 1.5000 volts, the output current will increase to 1.5000 milliamperes. Similarly, with the 10 MA range selected, 1.0000 volts input will produce a 10.000 milliampere output current. Increasing the input to 1.5000 volts will produce an output of 15.000 milliamperes. A positive polarity input will produce an output current of positive polarity and a negative input will produce an output of negative polarity. An AC input signal will produce an output current having the amplitude and phase characteristics of the applied input signal.

The maximum input voltage is ±3 volts DC or peak AC. Although the accuracy is not specified at inputs higher than ±2 volts DC or peak AC, the unit is usable with inputs up to ±3 volts DC or peak AC.

3.3 RANGE SWITCHING

Range switching is accomplished with a front panel six-station push button switch on the Model 2500-E and with remote signal inputs, as described in paragraph 2.5, on the Model 2500-EP. These ranges are defined in decade increments of 100uA, 1 MA, 100MA, 1A and 10A based on a 1-volt input. For example, with the 1MA range selected, a 1.0000 volt input will produce a 1.0000 milliampere output current. If a 1.0000 volt AC input is applied, the output current will be 1.0000 milliampere RMS and it will have the frequency and phase characteristics of the input.

As previously stated, the output current is proportional to the input voltage. Therefore, a 2-volt input will produce an output current which is 200% of the selected range (e.g., if the 1MA range is selected, the output current will be 2 milliamperes). The effective output impedance of the Calibrator approaches infinity. Therefore, the output circuit will attempt to deliver the selected current into any load impedance applied to the output terminals. A 1 milliampere current output applied to a 1K ohm load impedance produces 1 volt across that load impedance. A 1 milliampere output current applied to a 2K ohm load impedance produces 2 volts, etc., until the output voltage reaches the ±10-volt DC or peak AC maximum compliance level (±7 volts DC or peak AC on the 10A range). The 10 volts DC maximum compliance voltage corresponds to 7.07 volts RMS maximum compliance voltage for sine wave output currents.

3.4 ZERO ADJUSTMENT

A zero adjustment has been provided and is accessible through a hole in the front panel located just below and to the right of the input terminals. The instrument should be allowed to warm up for a period of one hour

prior to making the zero adjustment. To accomplish the zero adjustment, first short the input terminals together. Select the 1MA range and connect a precision 1K ohm resistor and a digital voltmeter (DVM) across the output terminals. If necessary, adjust the zero control until the DVM display reads ±100 microvolts DC or less.

3.5 OUTPUT VOLTAGE INDICATOR

The output voltage indicators consist of three colored LEDs; green, yellow and red. The green LED indicates that the output compliance voltage is within specification limits. The yellow LED indicates a near over-limit condition and the red LED indicates an over-limit condition. The green indicator will be illuminated when the compliance voltage is less than ±7 volts DC or peak AC. The green indicator is extinguished and the yellow indicator illuminated when the output compliance voltage is between ±7 and ±10 volts DC or peak AC. The yellow indicator is extinguished and the red indicator illuminated when the output compliance voltage exceeds ±10 volts DC or peak AC.

NOTE

The yellow LED is the over-limit indicator in the 10A range because of the ±7 volts DC or peak AC maximum output compliance voltage limitation on that range.

The over-limit indication occurs at a level below that where the specification limits are exceeded. When the over-limit indicator is on (red LED except in the 10A range where the yellow LED is the over-limit indicator) the operator should make a careful check of the test setup to verify proper operating conditions. Although the output specifications may be exceeded, the over-limit indication does not necessarily indicate non-linear operating conditions.

3.6 APPLICATION INFORMATION

The application of a precision constant current source, such as the Model 2500-E or Model 2500-EP Current Calibrators, requires a knowledge of potential outside error sources.

When measuring the DC current output of the AC-DC Current Calibrator, there are two primary potential error sources. The first occurs at the voltage input of the Current Calibrator. This error source is formed by the source impedance, R_S, of the input voltage source shown in Figure 3-1, forming a resistor divider with the 100K ohm input of the Current Calibrator, R_I. To maintain the error at 0.01% or less, the ratio of R_I:R_S must be maintained at 10,000:1 or greater. Since R_I equals 100K ohms, the maximum impedance for R_S must be less than 10 ohms. The second potential error source occurs at the current output of the AC-DC Current Calibrator. This error source is the shunt impedance of the DVM, R_Z, shown in Figure 3-1, in parallel with the load impedance, R_L. To maintain the error at 0.01% or less, the ratio of R_L:R_Z must be maintained at 10,000:1 or greater. If the input impedance of the DVM is 10M ohms, the maximum shunt impe-

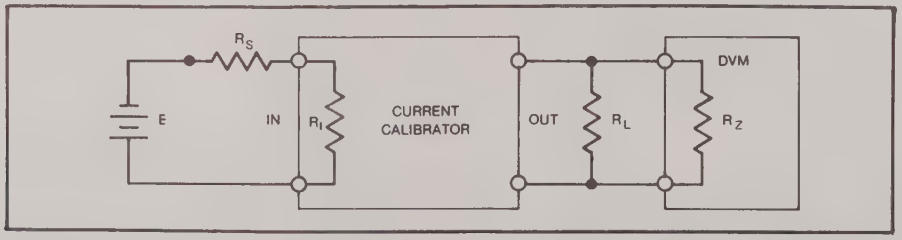


Figure 3-1. Block Diagram, DC Error Sources.

dance, R_L, should not exceed 1K ohms. For a shunt impedance, R_L, of 1M ohm, the input impedance of the DVM, R_Z, must be at least 10,000M ohms.

Measuring AC current introduces several new potential error sources in addition to those mentioned above. The most common error source is cable capacitance, C_C, shunted across the load as shown in Figure 3-2. If the output of the AC-DC Calibrator and the load are connected with five feet of RG58A/U cable, for example, the cable capacitance is 150 picofarads. If the output frequency is 5 KHz and the load resistance, R_L, is 10K ohms, the effective load impedance is:

$$Z = \frac{R_L\left(\frac{1}{2\pi \cdot 5\,KHz \cdot 150\,pf}\right)}{\sqrt{R_L^2+\left(\frac{1}{2\pi \cdot 5\,KHz \cdot 150\,pf}\right)^2}} = 9.989 \text{ kilohms}$$

The effective error due to shunt capacitance, C_C, is, in this case, 0.11%. As shown in the above equation, shunt capacitance versus load impedance is a square law function. Reducing the load impedance by a factor of 10 (10K ohms to 1K ohms) reduces the error by a factor of 100 (0.11% to 0.0011%). Another potential error source is caused by series inductance, L, in the load resistor, R_L. If the load resistance is 0.1 ohm at DC and the series inductance is 0.5 microhenries, the effective load impedance at 5 KHz is:

$$Z = \sqrt{R_L^2 + (2\pi \cdot 5\,KHz \cdot 5\,uH)^2} = 0.10123 \text{ ohm}$$

The effective error in load impedance caused by the series inductance, in this case, is 1.23%. A precise 10.000 RMS output current at 5 KHz from the AC-DC calibrator applied to this load produces a voltage drop of 1.0123 volts RMS. In practice, series inductance only becomes a problem for shunt impedances of less than 3 ohms at frequencies of 5 KHz and above. Most of the commercially available, laboratory-standard, 1-ohm resistors are not low enough in series inductance to be accurate at 1 ampere at 5 KHz. Special non-inductive precision current shunts are required to check the frequency response of the 1A and 10A ranges of the instrument.

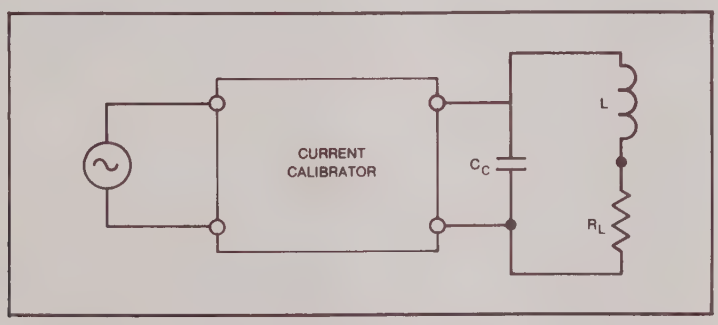


Figure 3-2. Block Diagram, AC Error Sources.

SECTION IV — THEORY OF OPERATION

4.1 GENERAL

This section of the manual describes the operation of the circuits of the Model 2500-E and Model 2500-EP Current Calibrators. The functional description of paragraph 4.2 is intended to assist the user in gaining a general understanding of instrument operation. It refers to the block diagram of Figure 4-1. Following the functional description are detailed circuit descriptions which refer to the schematic diagrams of Section V. The circuit descriptions are intended to provided the user with sufficient information on circuit operation to permit efficient troubleshooting. The information contained in this section, together with that of Section V, will provide the background necessary for maintaining the instrument.

4.2 FUNCTIONAL DESCRIPTION

The Model 2500-E and Model 2500-EP AC-DC Current Calibrators convert a precision input voltage to a precise output current with output polarity, or phase and frequency in the case of AC inputs, identical to the input.

4.2.1 INPUT AMPLIFIER

The input amplifier is a unity gain stage that converts the differential input signals to a single-ended output to drive the error amplifier. Circuitry is also provided to protect the input amplifier from accidental overloads.

4.2.2 ERROR AMPLIFIER

The error amplifier is a high gain, differential stage that compares the input

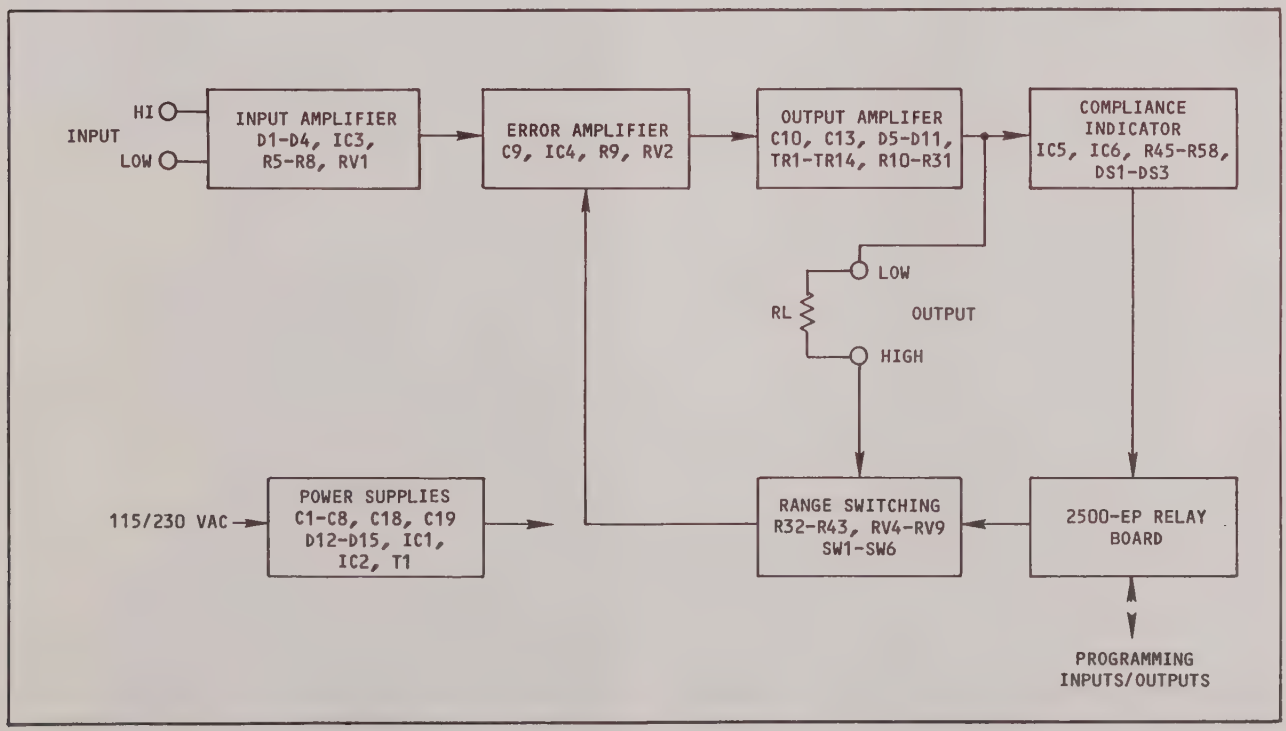


Figure 4-1. 2500-E/2500-EP Block Diagram.

signal, from the input amplifier, to the signal from the range switching circuitry, producing an error signal which drives the output amplifier. With an output load connected, negative feedback drives the difference between the two error amplifier inputs to zero.

4.2.3 OUTPUT AMPLIFIER

The output amplifier is a current booster stage capable of driving ±12 amperes into the load.

4.2.4 RANGE SWITCHING

The range switching circuitry selects one of six precision current shunts for the load current to pass through. The shunts are selected to produce one volt drop for each current range (e.g., 10 amperes in, 1 volt out, 1 ampere in, 1 volt out, etc).

4.2.5 OVERALL OPERATION

The operation of the Models 2500-E and 2500-EP is as follows: A one volt signal is applied to the input HIGH and LOW terminals. The input amplifier supplies a one volt output to the error amplifier which drives the output amplifier. The output current flows between the output LOW and HIGH terminals and through the selected current shunt. The voltage across the shunt is fed back into the error amplifier. Negative feedback drives both error amplifier inputs to the same value, controlling the output current.

4.2.6 COMPLIANCE INDICATOR

The compliance indicator senses the output voltage of the output amplifier. When this voltage exceeds the preset values, front panel LEDs indicate the output condition.

4.2.7 POWER SUPPLIES

The operating voltages for the Current Calibrator are provided by the power supply.

4.2.8 2500-EP RELAY BOARD

The Model 2500-E and Model 2500-EP use the same main PCB. The manual range switches of the 2500-E are replaced by the relay board. The relay board is programmed by external signals through a rear panel mounted connector. The relay board also provides a contact closure for each compliance indication range.

4.3 DETAILED CIRCUIT DESCRIPTION

The operation of the Models 2500-E and 2500-EP AC-DC Current Calibrators is described in detail in the following paragraphs.

4.3.1 INPUT AMPLIFIER

Operational amplifier IC3, along with resistors R5 through R8 and RV3, form a unity gain differential amplifier. Potentiometer RV3 compensates for any mismatch of R5 through R8. The DC zero of the amplifier is adjustable via RV1. Zener diodes D1 and D2 protect the input amplifier from overload by conducting when the input exceeds ±5 volts. Zener diodes D3 and D4 conduct when the output of IC3 exceeds ±7 volts.

4.3.2 ERROR AMPLIFIER

The error amplifier is comprised of C9, IC4, R9 and RV2. The DC offset of the error amplifier is adjustable via RV2. Resistor R9 and capacitor C9 provide error amplifier frequency compensation.

4.3.3 OUTPUT AMPLIFIER

The output amplifier consists of five pairs of complementary emitter followers (TR5 through TR14) driven from Darlington connected drivers TR3 and TR4. The output stage is driven through current sources comprised of D5 through D8, R12 through R17, and TR1 and TR2. The output stage

quiescent current is defined by diodes D9 through D11. High frequency signals are fed forward to the current sources by C10, C11, R10 and R11. The frequency compensation of the output stage is changed for different ranges by range switch sections SW1D through SW5D.

4.3.4 RANGE SWITCHING

The range switch, SW1 through SW6, selects the appropriate combination of current shunts (R33, R35, R37, R39, R41 and R43) for each range. The shunts are nominally high in value and are trimmed by RV4 through RV9. The 10 ampere range uses only R43. The 1 ampere range uses R41 and R43. Each lower current range uses the shunts from the higher current ranges.

4.3.5 COMPLIANCE INDICATOR

The output of the output amplifier is compared against two sets of complimentary voltage levels by window comparators comprised of IC5 and IC6. The positive voltage levels are determined by R45 through R47. The negative voltage levels are determined by R48 through R50.

4.3.6 POWER SUPPLIES

The AC line voltage is stepped down by transformer T1 and rectified by diodes D12 through D15 and filtered by C18 and C19 to provide ±20 volt rails. The ±20 volts are regulated down to ±15 volts by voltage regulators IC1 and IC2. The ±15 volt rails are filtered by capacitors C3 and C4. Two sets of decoupled +15 volt power sources are provided to power IC3 and IC4. Decoupling is accomplished by R1 through R4 and C5 through C8.

4.3.7 2500-EP RELAY BOARD

In the Model 2500-EP, the relay board replaces the range switch, SW1 through SW6, of the Model 2500-E with six four-pole relays. These relays perform the same functions as the range switches. To reduce the programming control current to TTL compatible levels, the six four-pole relays are driven by six reed relays, RLA through RLF. Diodes D1 through D6 snub the inductive kick from the relay coils. The range LEDs, DS1 through DS6, indicate which current range is selected. Relays RLN, RLP and RLR are driven by transistors TR1 through TR3 to provide relay contact closure for each compliance range.

SECTION V — MAINTENANCE

5.1 INTRODUCTION

This section of the manual contains information necessary for maintenance of the Models 2500-E, 2500-EP and 2500-EN AC-DC Current Calibrators. Included are a list of required test equipment and calibration procedures.

5.2 REQUIRED TEST EQUIPMENT

The following items of test equipment are required to calibrate the Models 2500-E and 2500-EP and 2500-EN:

DC Voltage Standard
Valhalla Scientific Model 2701B, or equivalent. 0 to 1V DC, ±0.003% accuracy (0 to 10V DC, ±0.003% for Model 2500-EN).

Five-Digit Digital Voltmeter (DVM)
±0.003% accuracy, 10M ohms minimum input impedance on 1 volt range.

Precision DC Shunt Resistors
0.10000 ohm ±0.003%
1.0000 ohm ±0.003%
10.000 ohm ±0.003%
100.00 ohm ±0.003%
1000.0 ohm ±0.003%
10000 ohm ±0.003%

5.3 CALIBRATION PROCEDURE

The following procedure should be performed on a routine basis to insure that the instrument remains within its specifed accuracy. The calibration procedure should be performed after repairs are made to any of the accuracy determining components. Apply AC power and allow one hour for the instrument to stabilize.

5.4 OFFSET AND CMRR ADJUSTMENT

These adjustments are not part of the routine calibration procedure and are not required unless repairs have been made.

5.4.1 OFFSET ADJUSTMENT 1

Short the output terminals, select the standby mode and the 1 amp range. Connect the DVM to pin 6 of IC3 and 0V signal (bottom of R8). Adjust RV1 for 0.000 mV.

5.4.2 CMRR ADJUSTMENT

Short the output terminals, select the standby mode and the 1 amp range. Apply 10.00 volts between the input low terminal and 0V signal (bottom of R8). Connect the DVM to pin 6 of IC3 and 0V signal. Adjust RV3 for 0.000 volt.

5.4.3 OFFSET ADJUSTMENT 2

Connect a 1.00K ohm resistor and the DVM to the output terminals, short the input terminals and adjust RV2 for 0.000 volt across the resistor.

5.5 ZERO ADJUSTMENT

Short the input terminals and connect the DVM and 1K ohm shunt to the output terminals and select the 1MA range. Adjust the zero potentiometer, RV1, for a DVM reading of ±100 microvolts or less.

5.6 RANGE ADJUSTMENTS

Connect the DC Voltage Standard to the input terminals and apply 1.0000 volts (apply 10.000 volts for the Model 2500-EN).

5.6.1 10 AMPERE RANGE

Connect the DVM and a 0.1000 ohm shunt to the output terminals and select the 10A range. Adjust RV4 for a DVM reading of 1.000 volts ±500 microvolts or less.

5.6.2 1 AMPERE RANGE

Connect the DVM and a 1.0000 ohm shunt to the output terminals and select the 1A range. Adjust RV5 for a DVM reading of 1.000 volts ±500 microvolts or less.

5.6.3 100 MILLIAMPERE RANGE

Connect the DVM and a 10.000 ohm shunt to the output terminals and select the 100MA range. Adjust RV6 for a DVM reading of 1.000 volts ±500 microvolts or less.

5.6.4 10 MILLIAMPERE RANGE

Connect the DVM and a 100.00 ohm shunt to the output terminals and select the 10MA range. Adjust RV7 for a DVM reading of 1.000 volts ±500 microvolts or less.

5.6.5 1 MILLIAMPERE RANGE

Connect the DVM and a 1000.0 ohm shunt to the output terminals and select the 1MA range. Adjust RV8 for a DVM reading of 1.000 volts ±500 microvolts or less.

5.6.6 100 MICROAMPERE RANGE

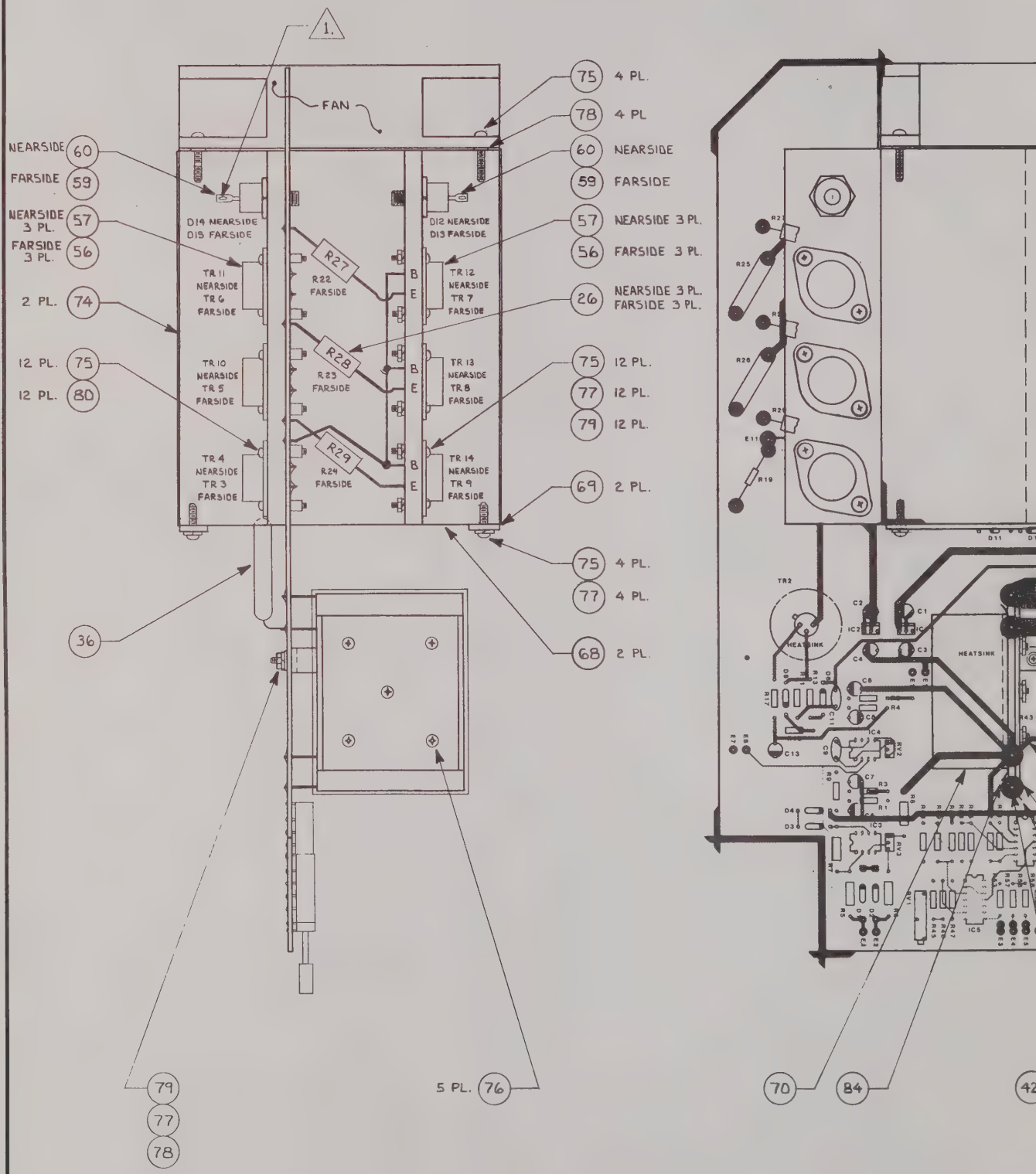
Connect the DVM and a 10000 ohm shunt to the output terminals and select the 100uA range. Adjust RV9 for a DVM reading of 1.000 volts ±500 microvolts or less.

SECTION VI — PARTS LISTS

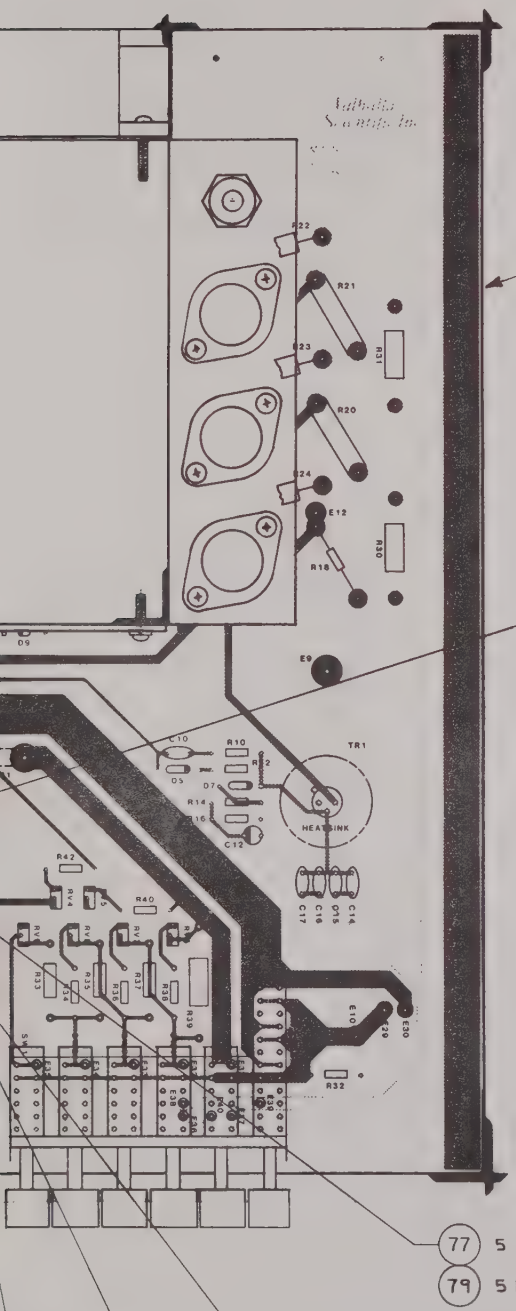
6.1 GENERAL

The parts lists of this section are reproductions of factory parts lists. The designators are those of the diagrams in Section V. When ordering replacement parts, provide the reference designator, manufacturer's part number, manufacturer's name and Valhalla part number if contained in the parts list. The manufacturer is identified in the parts list by a federal stock number. A list of manufacturer's federal stock codes is provided as an appendix to this manual for identification of manufacturer's.

NOTES: (UNLESS OTHERWISE SPECIFIED)



REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASED W.P.W.	8-29-83	
0117	B	SEE ECO W.P.W.	8-29-83	PW



1 P.C. BOARD

76
78

77 5 PL.
79 5 PL.

84

71

NOTES:

1. INSTALL 6-32 × ½" SCREWS INTO DIODE PINS TO ATTACH WIRES.
2. NEARSIDE AND FARSIDE OF HEATSINK ASSY.S ARE SIMILIAR.
3. INSTALL ITEMS 80 (12 PER) FIRST.
4. HEATSINK INSULATORS ARE TO BE TAPED ON TO HEATSINKS.

DASH NO	QTY REQD	NEXT ASSEMBLY	USED ON

TOLERANCES
X° = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 63

MATERIAL

FINISH

DRAWN	W.P.W.	8-29-83
CHECKED	PW	9-2-83
APPR	PW	9-2-83
STK NO		

Valhalla Scientific Inc.
SAN DIEGO, CA

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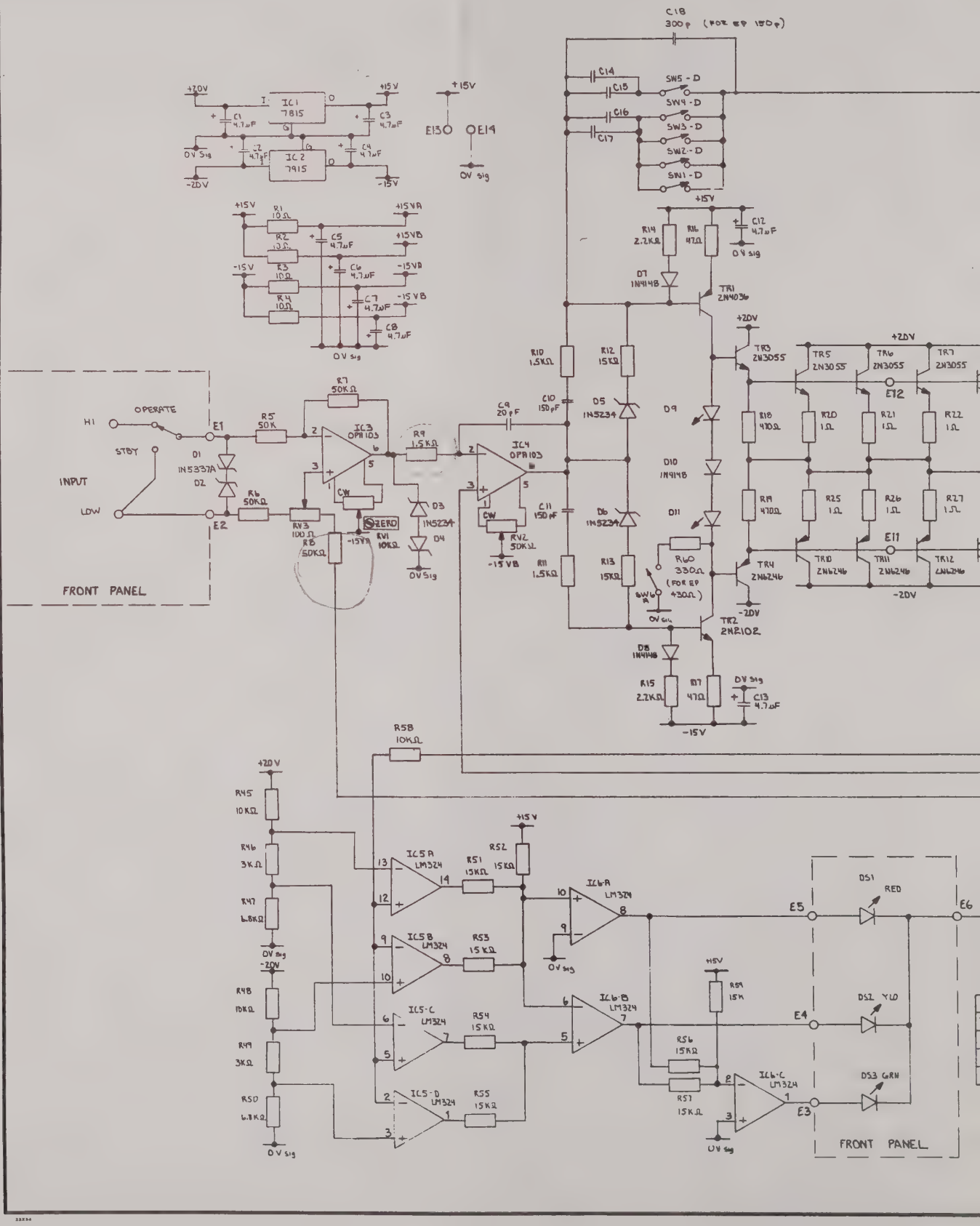
MAIN P.C.B. BOARD

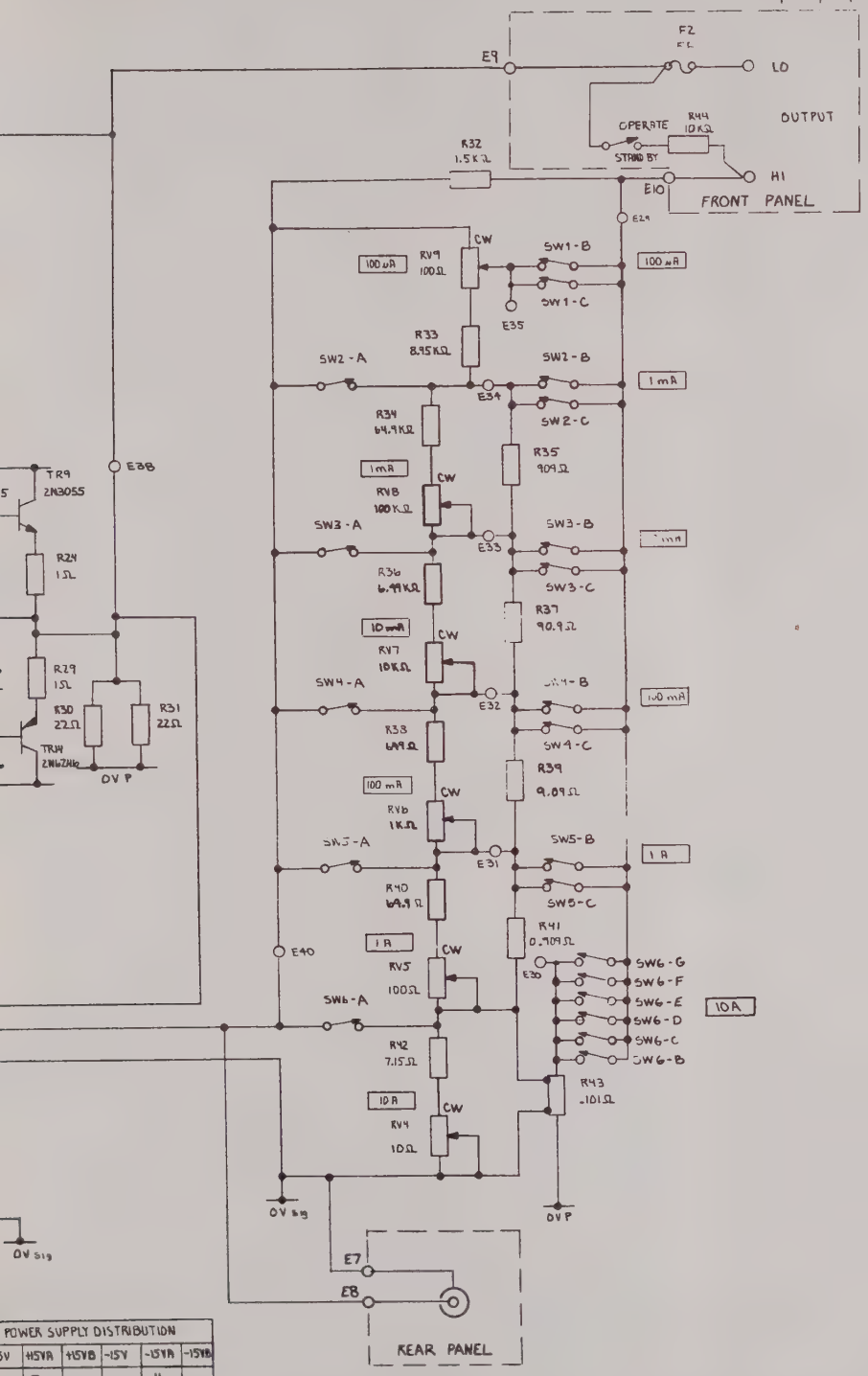
SCALE	CODE IDENT	SIZE	DRAWING NO	REV
NONE	53504	D	2500-603	B

SHEET 5 OF 5

NOTES: (UNLESS OTHERWISE SPECIFIED)



REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
2182	B	ECO # 83-203-2 W	10/21/83	PWD



POWER SUPPLY DISTRIBUTION					
5V	+5VA	+5VB	-15V	-15VA	-15VB
—	7	—	—	4	—
—	—	7	—	—	4
—	—	—	11	—	—

FIRST USED	NOT USED	LAST USED
C1	—	C18
D1	—	D11
IC1	—	IC6
R1	—	R60

TOLERANCES
X = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 64

MATERIAL

FINISH

DRAWN JM	2-83	
CHECKED PW	10-83	
APPR PW	10-83	
STK NO		

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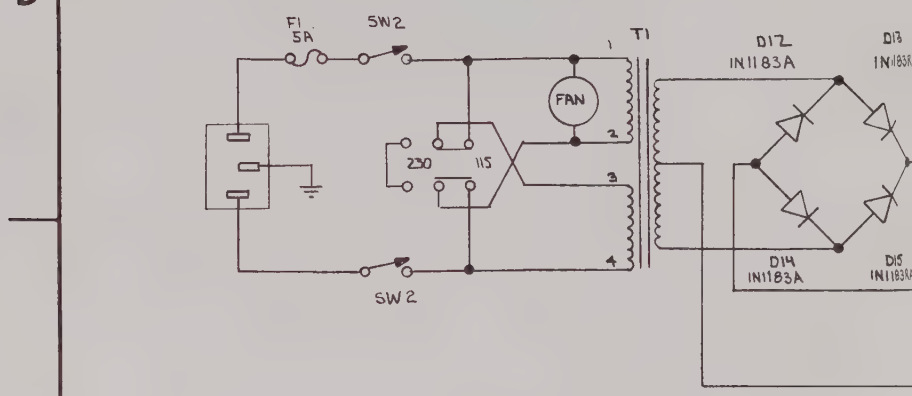
Valhalla Scientific Inc.
SAN DIEGO, CA

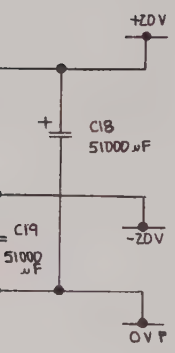
MAIN BOARD SCHEMATIC 2500E

SCALE	CODE IDENT	SIZE	DRAWING NO	REV
	53504	D	2500 - 073	B

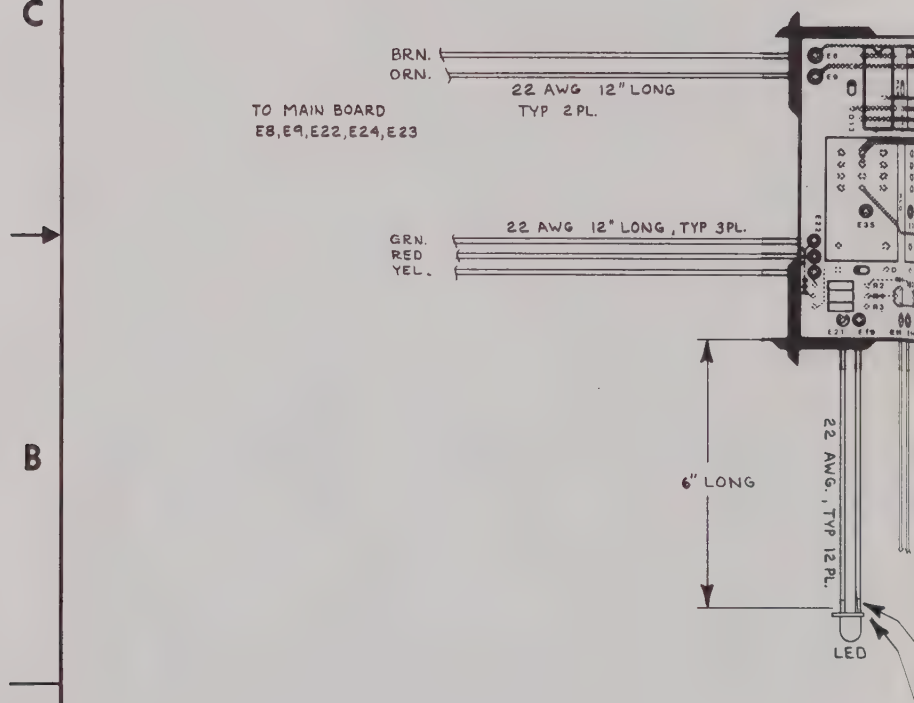
SHEET 1 OF 2


F1
5A
SW2
T1
FAN
230
115
SW2
D12
IN1183A
D14
IN1183A
D15

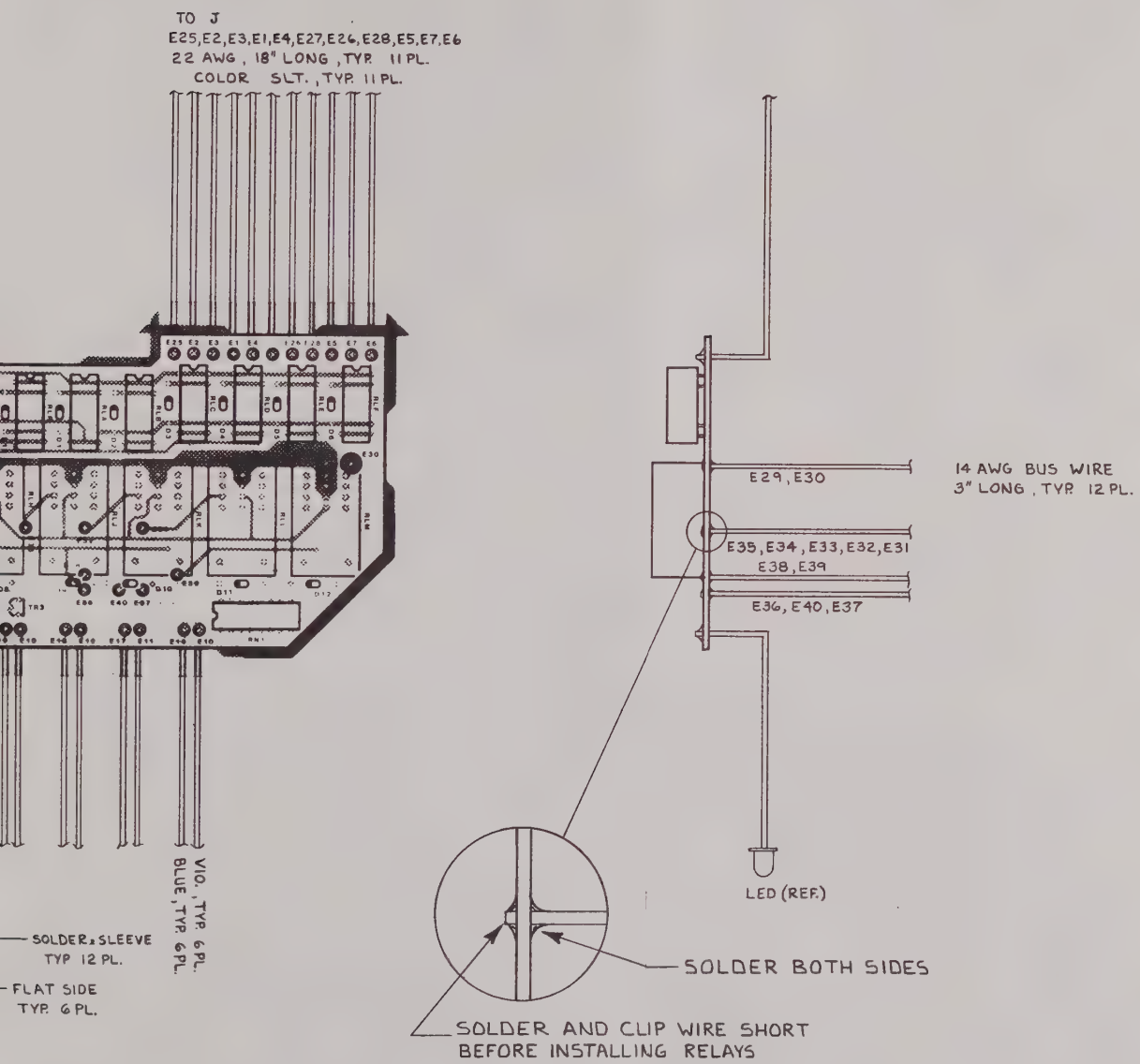
REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED



				TOLERANCES	MATERIAL	DRAWN JW	2-83	Valhalla Scientific Inc. SAN DIEGO, CA
				X = ± 30'		CHECKED		
				.XX = ± .03		APPR		
				.XXX = ± .010		STK NO		
				BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 64	FINISH	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC INC AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT VALHALLA SCIENTIFIC INC RESERVES ALL PATENT SALE PROPRIETARY DESIGN MANUFACTURING USE AND REPRODUCTION RIGHTS THERETO	2500 E	
H	QTY REQD	NEXT ASSEMBLY	USED ON			SCALE	CODE IDENT 53504	SIZE C / DRAWING NO 2500-073 / REV B
						SHEET 2 OF 2		


BRN.
ORN.
22 AWG 12" LONG
TYP 2 PL.
TO MAIN BOARD
E8, E9, E22, E24, E23
GRN.
RED
YEL.
22 AWG 12" LONG, TYP 3PL.
6" LONG
22 AWG., TYP 12 PL.
LED

REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASED W.P.W.	9-6-83	



SH	QTY REQD	NEXT ASSEMBLY	USED ON

TOLERANCES
X° = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES
63

MATERIAL

FINISH

DRAWN W.P.W	9-6-83	
CHECKED	9-6-83	
APPR PW	9-6-83	
STK NO		

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Valhalla Scientific Inc.
SAN DIEGO, CA

"2500EP" RELAY BOARD ASSY.

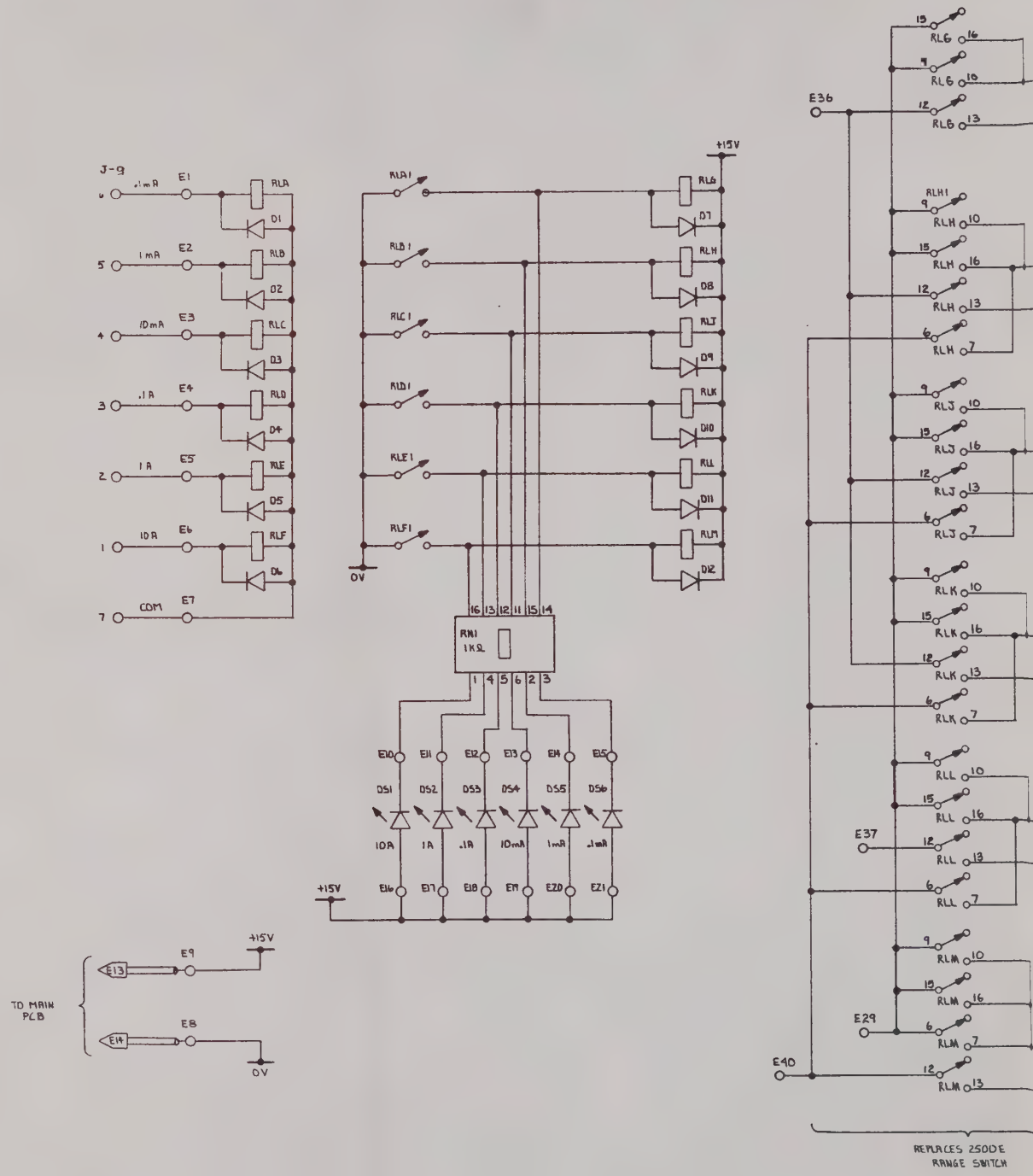
SCALE	CODE IDENT	SIZE	DRAWING NO	REV
NONE	53504	C	2500-602	A

SHEET ___ OF ___

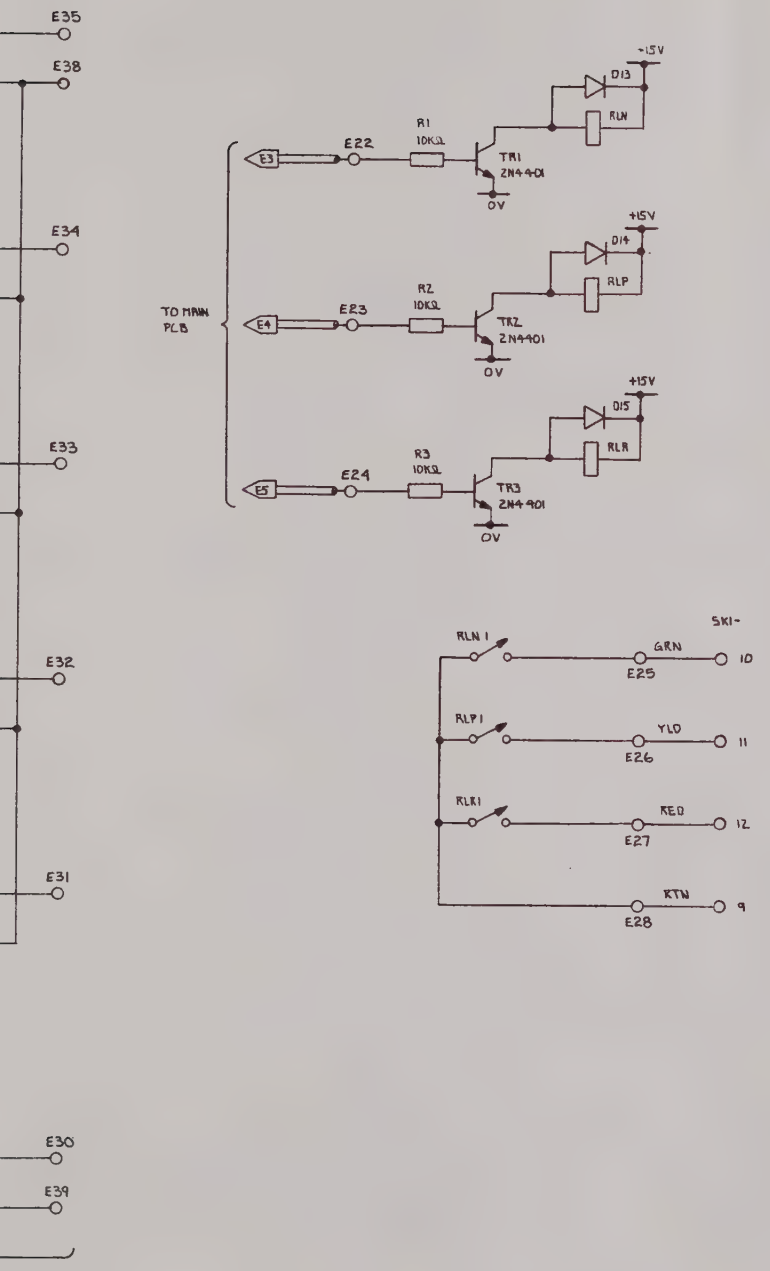
2500-602 A

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL DIODES 1N4148.



REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
3 5 [illegible]	B	[illegible]	10/21/83	PW



FIRST USED	NOT USED	LAST USED
D1		D15
DS1		DS6
R1		R3
RN1		RN1
RLA	RL1, RL0, RL0	RLR
TR1		TR3

TOLERANCES
X = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 64

MATERIAL

FINISH

DRAWN	JW	9-20-83
CHECKED	PW	10-21-83
APPR	PW	10-21-83
STK NO		

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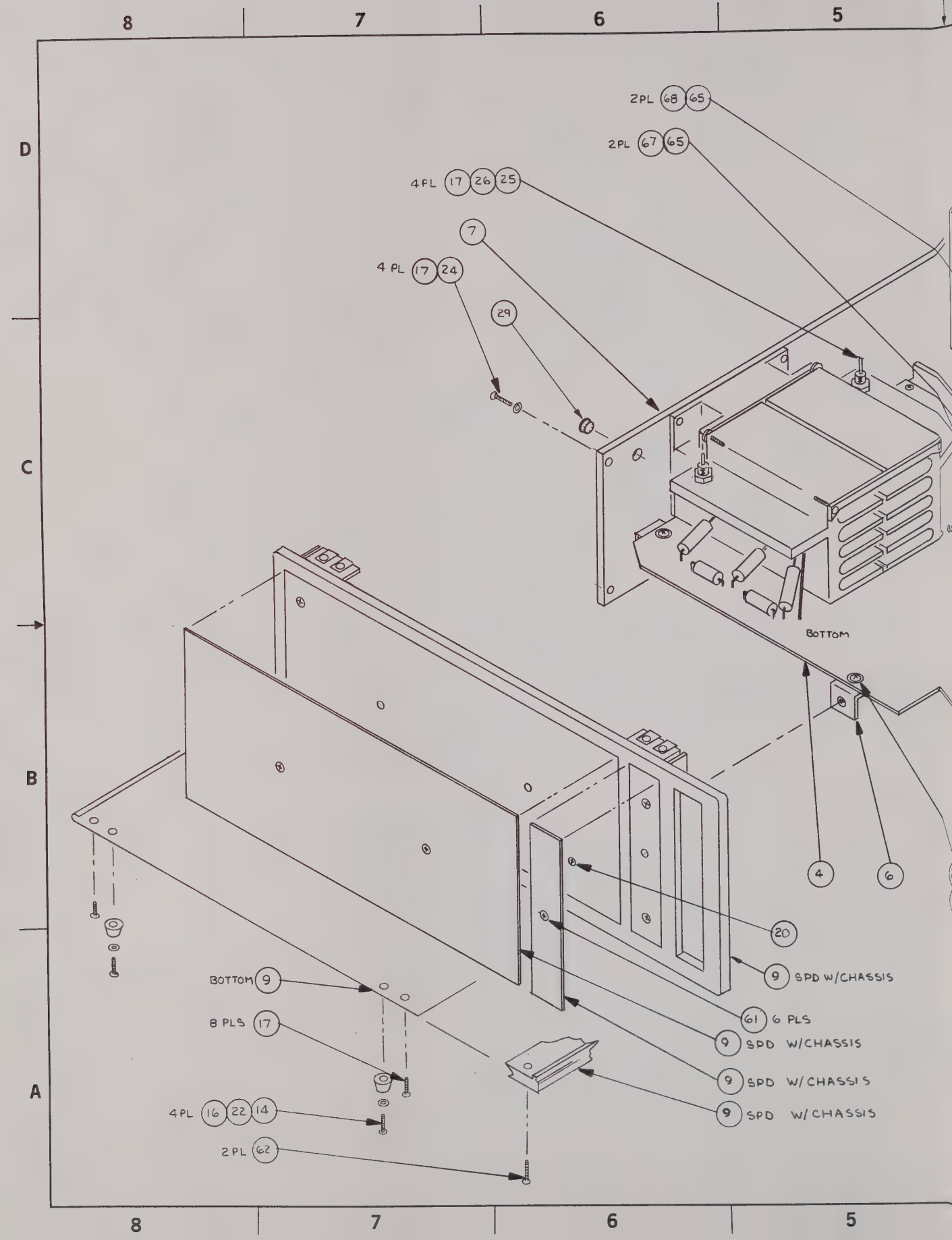
Valhalla Scientific Inc.
SAN DIEGO, CA

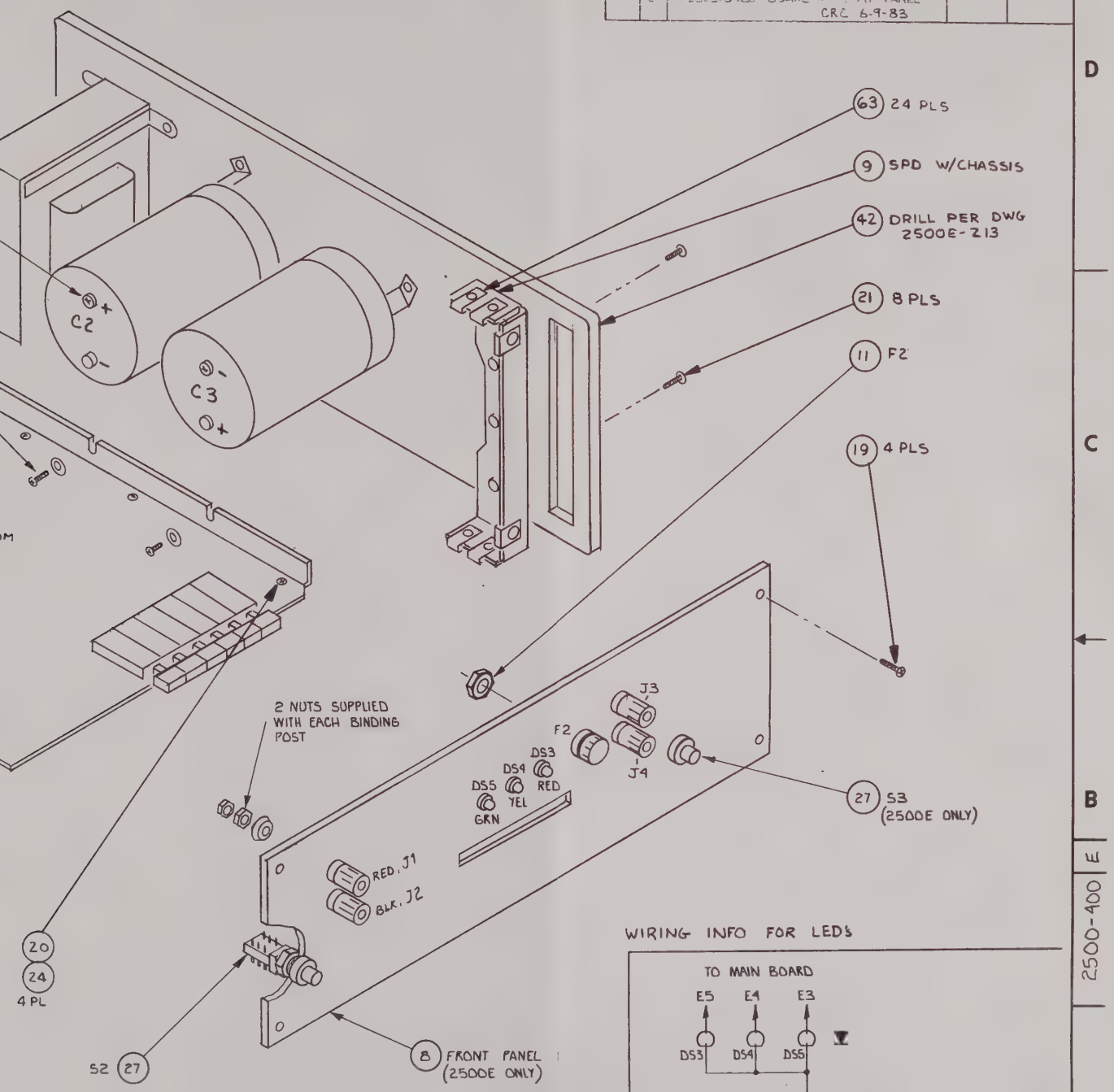
2500 EP RELAY BOARD

SCALE	CODE IDENT	SIZE	DRAWING NO	REV
	53504	D	2500-072	B

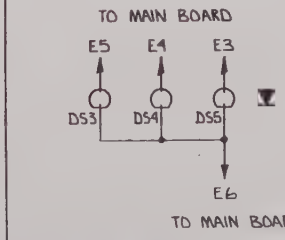
SHEET 1 OF 1


8
7
6
5
D
C
B
A
2PL 68 65
2PL 67 65
4PL 17 26 25
7
4 PL 17 24
29
BOTTOM
4
6
20
9 SPD W/CHASSIS
61 6 PLS
9 SPD W/CHASSIS
9 SPD W/CHASSIS
9 SPD W/CHASSIS
BOTTOM 9
8 PLS 17
4PL 16 22 14
2PL 62

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	D	RELEASED		
	E	REDESIGNED BOARD & FRONT PANEL CRC 6-9-83		



WIRING INFO FOR LEDS

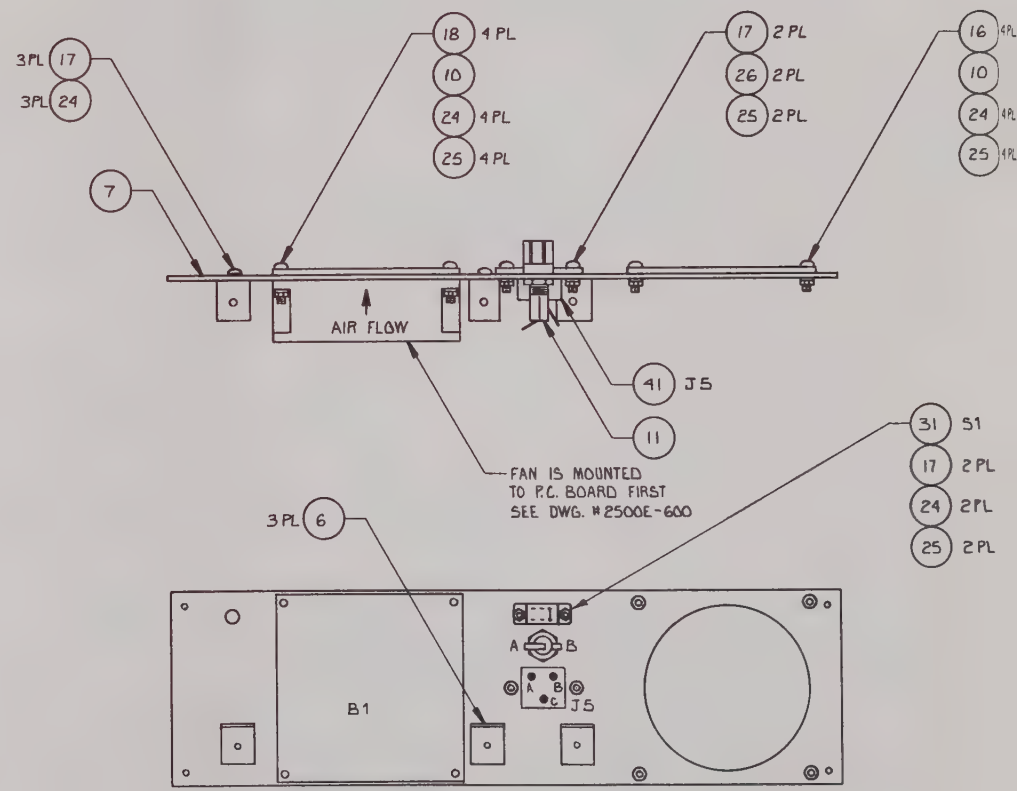


3. FOR WIRING SEE 2500E-050
2. FOR SCHEMATIC SEE 2500E-073
1. FOR MODS TO MAKE 2500EP SEE PARTS LIST 2500-401

NOTES:

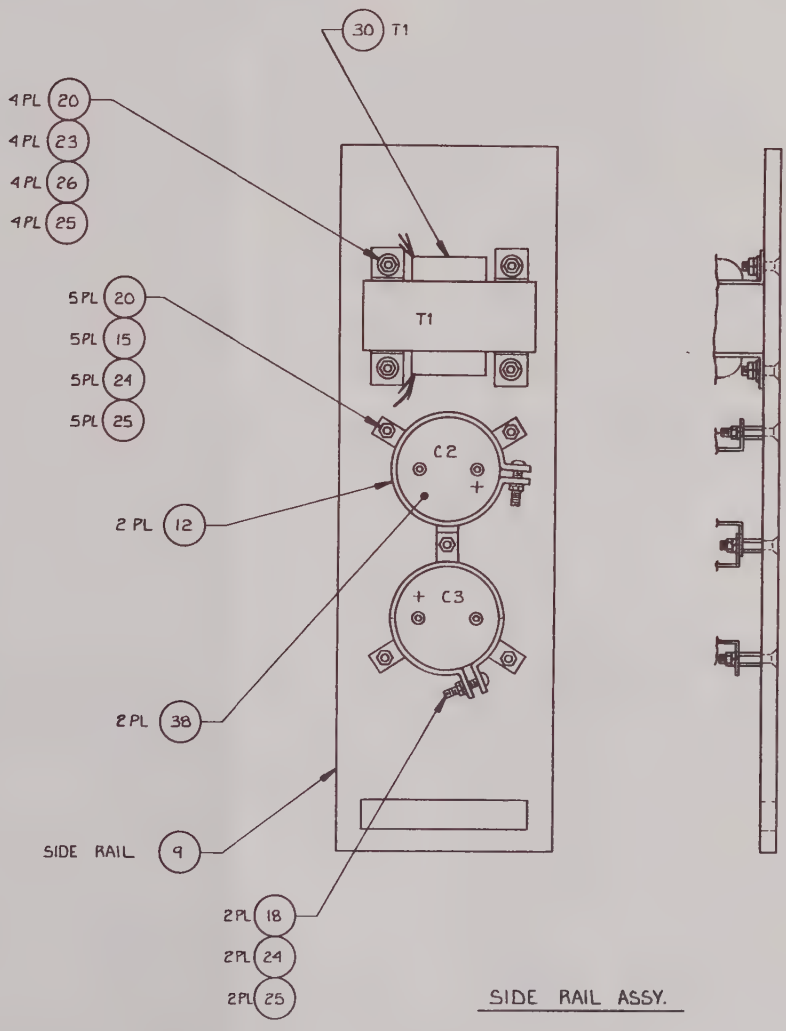
MATERIAL	DRAWN RM 4/82	Valhalla Scientific Inc.	
	CHECKED	SAN DIEGO, CALIFORNIA	
	APPR.		
FINISH	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND EXCEPT FOR PRODUCTS SOLD BY VALHALLA SCIENTIFIC, INC. IS LOANED SUBJECT TO RETURN ON DEMAND. VALHALLA SCIENTIFIC, INC. RESERVES ALL PATENT, SALE, PROPRIETARY, DESIGN, MANUFACTURING, USE AND REPRODUCTION RIGHTS THEREIN	FINAL ASSEMBLY 2500E / 2500EP	
	SCALE NONE	CODE IDENT NO. 53504 / SIZE D / DRAWING NO. 2500 -400 / REV. E	
	SHEET 4 OF 5		

2500-400 E



SHOWN IS ASSY. OF REAR PANEL

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	E	[illegible]		



SIDE RAIL ASSY.

MATERIAL	DRAWN C.R.E. 4/82	Valhalla Scientific Inc. SAN DIEGO, CALIFORNIA			
	CHECKED				
	APPR.				
FINISH	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT, VALHALLA SCIENTIFIC, INC. RESERVES ALL PATENT, SALE, PROPRIETARY, DESIGN, MANUFACTURING AND REPRODUCTION RIGHTS THERETO	FINAL ASSEMBLY 2500E / 2500EP			
	SCALE NONE	CODE IDENT NO 53504	SIZE D	DRAWING NO. 2500 - 400	REV. E
	SHEET 5 OF 5				

2500-400

Valhalla Scientific Inc.

PARTS LIST

CURRENT CALIBRATOR

MODEL	DWG NO	REV
2500E	2500E-400	E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
1			ASSY.		2500E-400						
2											
3											
4			P.C. Board Assy.	53504	2500E-603A	1					
5		4-10050	Ground Bracket	53504	2500-207C	1					
6		4-10051	Mtg. Bracket	53504	2500-208	4					
7		4-10052	Rear Panel	53504	2500-209B	1					
8		4-10053	Front Panel	53504	2500-210F	1					
9		4-10223	Chassis Assy.	TDJ	B-525-15-1700H	1					
10		5-10060	Finger Guard	02660	760-9601-43	2					
11		5-10018	Fuse Holder	75915	34 2004A	2					
12		5-10062	Capacitor Mtg. Bracket	90201	VR12	2					
13		5-10067	Power Cord	70903	17250	1					
14		5-10015	Rubber Feet		2084 BLK/478	4					
15		5010217	Spacer,1/4HEX,1/4LG	83330	2300	5					
16			Screw,Phil,Pan,Cad		6/32 x 3/4"	8					
17			Screw,Phil,Pan,Cad		6/32 x 3/8"	23					
18			Screw,Phil,Pan,Cad		6/32 x 1"	6					
19			Screw,Phil,Pan,Blk		6/32 x 3/8"	4					
20			Screw,Phil,Flat,Cad		6/32 x 5/8"	15					
21			Screw,Phil,Flat,Stainless		6/32 x 3/8"	8					
22			Washer,Flat		#6	4					

NOTES:

Valhalla Scientific Inc.	PARTS LIST	CURRENT CALIBRATOR	MODEL 2500E	DWG NO 2500E-400	REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
23			Washer, Flat		#10	4					
24			Washer, Split Lock		#6	30					
25			Standard HEX Nut		#6	28					
26			Washer, Internal Star		#6	10					
27	S2,S3	5-03061	Power Switch	SCHADOW	ZFNE15	2					
28											
29		5-10291	Plug Hole	83330	3091	1					
30	T1	4-20009	Power Transformer	53504	2500-011	1					
31	S1	5-03017	Switch Slide 115/220	82389	47227LFR	1					
32	DS3	5-01011	LED, Red, Panel Mtg.	82480	5082-4655	1					
33	DS4	5-01012	LED, Yel, Panel Mtg.	82580	5082-4555	1					
34	DS5	5-01013	LED, Grn, Panel Mtg.	82580	5082-4955	1					
35	R44	1-01061	EWA, 10K, 1/4W	81349	RC07GF103J	1					
36	F1	5-04009	Fuse 5A	75915	3AG5A	1					
37	F2	5-04005	Fuse 15A	75915	3AG10A	1					
38	C2,C3	2-40003	Cap,Elec,6100mf/40V	00853	DCM613U0400D2B	2					
39	J1,J3	5-10021	Binding Post, Red	83330	257 Red	2					
40	J2,J4	5-10020	Binding Post, Blk	83330	257 Blk	2					
41	J5	5-10063	Power Recpt.	82389	EAC301	1					
42			Side Rail, Modified	53504	2500E-213A	1					
43			12 AWG, Blk, 9 Ft.			1					
44			12 AWG, Grn, 5 Ft.			1					
45			20 AWG, Grey, 1 Ft.			1					

NOTES:

Valhalla Scientific Inc.	PARTS LIST	CURRENT CALIBRATOR	MODEL 2500E	DWG NO 2500E-400	REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
46			20 AWG, ORN, 1 ft.			1					
47			20 AWG, VIO, 1 ft.			1					
48			20 AWG, YEL, 1 ft.			1					
49			20 AWG, GRN, 1 ft.			1					
50			20 AWG, RED, 1 ft.			1					
51			20 AWG, BLUE, 1 ft.			1					
52			20 AWG, BRN, 6 inches			1					
53			20 AWG, WHT, 1 ft.			1					
54			16 AWG, RED, 5 ft.			1					
55			16 AWG, BLK, 5 ft.			1					
56		5-10123	Ring Lug #6/22AWG		PV24-6R	3					
57		5-10140	Ring Lug #6/14AWG		PV14-6R	8					
58			16 AWG,GRN, 6 inches			1					
59			Ring Lug #10/14AWG		PV14-10R	2					
60											
61			Screw,Phil,Oval, CAD		6-32-3/8	6					
62	SUPPLIED WITH CASE		Screw,Phil,Oval,CAD		6-32-1/2	2					
63			Tinnerman Nut		6-32	24					
64		5-10019	Ty Wraps			50					
65			Washer, Internal Star		#10	4					
66		5-10261	Ty Wrap Blocks			10					
67			Screw,Phil,Pan,CAD		#10-32 x 7/16	2					
68	Supplied with C2+3		Screw,Phil,Pan,CAD		10-32 x 1/4	2					

NOTES:

Valhalla Scientific Inc.	PARTS LIST	2500EP ASSEMBLY	MODEL 2500EP	DWG NO 2500-401	REV B

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
			2500EP ASSY		2500-401	X					
1			Chassis Assy.	53504	2500-400E	1					
2											
3	Remove:	4-10053	FRONT PANEL	53504	2500-210F	1					
4	ADD:	4-10149	Front Panel	53504	2500-223C	1					
5											
6	Remove:	4-10052	Rear Panel	53504	2500-209B	1					
7	ADD:	4-10377	Rear Panel	53504	2500-225B	1					
8											
9	Remove: S1-S6	5-03008	Switch Range	53504	5-03008	1					
10	ADD: A2		Relay Bd. Assy.	53504	2500-602A	1					
11											
12		5-10020	Binding Post, BLK	Superior	PB30BC	2					
13		5-10021	Binding Post, RED	Superior	PB30RC	2					
14											
15			Wire, RED, 4 ft.	81349	12 AWG RED	1					
16			Wire, BLK, 4 ft.	81349	20 AWB BLK	1					
17	Remove: S3	5-03061	Switch, Stand By	Schadow	ZFNE15	1					
18	Remove C18	2-20020	Cap,MICA 300pF		CM05FD301J03	1					
19	ADD: C18	2-20007	Cap, MICA 150pF		CM05FD151J03	1					
20	Remove R60	1-01030	Resistor, 330 ohm		RC07GF331J	1					
21	ADD: R60	1-01032	Resistor, 430 ohm		RC07GF431J	1					

NOTES:

Valhalla Scientific Inc.

PARTS LIST

RELAY BOARD | MODEL 2500EP | DWG NO 2500-602 | REV B

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
			RELAY BD. ASSY.		2500-602	X					
1		4-30040	P.C. Board (Relay)	53504	2500-702A	1					
2											
3	D1-D15	3-20000	Diode, Signal	MOT	IN4148	15					
4	DS1-DS6	5-01011	LED, Red, Panel Mtg.	H.P.	5082-4655	6					
5											
6	R1-R3	1-01061	RES, FXD 10Kohm 1/4W	81349	RC07GF103J	3					
7	RN1	1-40008	RES, NET 1Kohm 1/4W	81349	316B-102	1					
8											
9	RLA-RLF	5-03012	Relay, Reed 5V	Clair	PRMEIA005	6					
10	RLG,RLH,RLJ,RLM	5-03019	Relay, 4 PDT,13V	P&B	R10E2Z410K	6					
11	RLN,RLP,RLR	5-03070	Relay,Reed 15V	Clair	PRMA1A12	3					
12											
13	TR1-TR3	3-10013	Transistor, NPN	MOT	2N4401	3					
14											
15			WIRE, BRN, 38"	81349	22AWG,BRN	1					
16			WIRE, RED, 38"	81349	22 AWG, RED	1					
17			WIRE,ORN, 24"	81349	22 AWG, ORN	1					
18			WIRE, YEL, 18"	81349	22 AWG, YEL	1					
19			WIRE, GRN, 18"	81349	22 AWG, GRN						

NOTES: SHT 3 of 3 IS ASSY. DWG.

Valhalla Scientific Inc.

PARTS LIST

RELAY BOARD | MODEL 2500EP | DWG NO 2500-602 | REV B

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
20			WIRE, BLUE, 18"	81349	22 AWG, BLUE	1					
21			WIRE, VIO., 12"	81349	22 AWG, VIO.	1					
22			WIRE, SLT., 12"	81349	22 AWG, Grey	1					
23			WIRE, WHT., 12"	81349	22 AWG, WHT.	1					
24			WIRE, BLK., 12"	81349	22 AWG, BLK.	1					
25											
26			WIRE, BUSS, 8"	81349	16 AWG	1					
27			WIRE, BUSS, 2"	81349	20 AWG	1					
28											
29			SHRINK TUBING 12"	81349	1/16" BLK	1					
30											
31		5-10089	CONNECTOR 14 PIN "D"	02660	57-40140	1					30140, 30141

NOTES:

Valhalla Scientific Inc.

PARTS LIST

MODEL	DWG NO	REV
2500E	2500-603	C

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
			MAIN BD. ASSY.	53504	2500-603	X					
1	A1	4-30015	P.C. Board (Main)	53504	2500-703A	1					
2											
3	C1-8,12,13	2-30011	CAP. 4.7pf TANT.	05397	T360B475M035AS	10					
4	C9	2-20014	CAP. 20pf, MICA		CM05FD200J03	1					
5	C10,11	2-20007	CAP. 150pf MICA		CM05FD151J03	2					
6	C14-17		CAP. TO BE DETERMINED			4					
7	C18	2-20020	CAP. 300pf MICA		CM05FD301J03	1					
8	D1,2	3-20031	DIODE ZENER	04713	IN5337A	2					
9	D3-6	3-20005	DIODE ZENER, 6V	04713	IN5234	4					
10	D7,8,10	3-20000	DIODE SIGNAL	04713	IN4148	3					
11	D9,11	5-01005	LED, RED	00001	MV5074	2					
12											
13	IC1	3-30142	IC, Voltage, REG	27014	7815C	1					
14	IC2	3-30143	IC, Voltage REG	27014	7915C	1					
15	IC3, 4	3-30315	IC, OP-AMP		OPA103CM	2					
16	IC5,6	3-30031	IC,QUAD OP-AMP	27014	LM324N	2					
17											
18	R1-4	1-01007	RES.,10 ohm 1/4W	81349	RC07GF100J	4					
19	R5-8	1-20034	RES., 50K, .01%	53504	1-20034	4					
21											

NOTES: SHT. 5 IS ASSY. DWG.

Valhalla Scientific Inc.

PARTS LIST

MODEL	DWG NO	REV
2500E	2500-603	C

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
22	R12,13,51-57,59	1-01063	RES,15K, 1/4W	81349	RC07GF153J	10					
23	R14,15	1-01046	RES,2.2K, 1/4W	81349	RC07GF222J	2					
24	R16,17	1-01015	RES, 47ohm, 1/4W	81349	RC07GF470J	2					
25	R18,19	1-01033	RES., 470 ohm, 1/4W	81349	RC07GF471J	2					
26	R20-29	1-30001	RES., 1 ohm, 8W	44655	1500-1 ohm	10					
27	R30,31	1-30021	RES., 22 ohm, 2W	81349	RC42GF220J	2					
28	R33	1-20051	RES., 8.95K, 1% WW	53504	1-20051	1					
29	R34	1-10072	RES., 64.9K, 1%	81349	RN60C6492F	1					
30	R34	1-20050	RES., 909 ohm, WW	53504	1-20050	1					
31	R36	1-10071	RES., 6.49K, 1%	81349	RN60C6491F	1					
32	R37	1-20049	RES., 90.9 ohm, WW	53504	1-20049	1					
33	R38	1-10070	RES., 649 ohm, 1%	81349	RN60C6490F	1					
34	R39	1-20048	RES., 9.09 ohm, WW	53504	1-20048	1					
35	R40	1-10069	RES., 64.9 ohm, 1%	81349	RN60C649RF	1					
36	R41	1-20047	RES., .909 ohm, WW	53504	1-20047	1					
37	R42	1-10068	RES., 7.15 ohm, 1%	81349	RN60C7R15F	1					
38	R45, 48, 58	1-01061	RES., 10K, 1/4W	81349	RC07GF103J	3					
39	R46,49	1-01049	RES., 3K, 1/4W	81349	RC07GF302J	2					
40	R47,50	1-01057	RES., 6.8K 1/4 W	81349	RC07GF682J	2					
41	R58	1-01041	RES., 1K, 1/4 W	81349	RC07GF102J	1					
42	R43	1-20046	RES., .101 ohm	53504	1-20046	1					
43	R60	1-01030	RES., 330 ohm	81349	RC07GF331J	1					
44											

NOTES:

Valhalla Scientific Inc.

PARTS LIST

MODEL	DWG NO	REV
2500E	2500-603	C

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
45	RV1	1-50016	RES., Variable, 10K	73138	89XR-10K	1					
46	RV2	1-50028	RES., Variable, 50K	73138	68WR-50K	1					
47	RV3,5,9	1-50014	RES., Variable, 100 ohm	73138	68WR-100 ohm	3					
48	RV4	1-50018	RES., Variable, 10 ohm	73138	68WR-10 ohm	1					
49	RV6	1-50013	RES., Variable, 1K	73138	68WR-1K	1					
50	RV7	1-50012	RES., Variable, 10K	73138	68WR-10K	1					
51	RV8	1-50024	RES., Variable, 100K	73138	68WR-100K	1					
52											
53	SW1-6	5-03008	Switch Range	53504	5-03008	1					
54	TR1	3-10002	Transistor, PNP	04713	2N4036	1					
55	TR2	3-10007	Transistor, NPN	04713	2N2102	1					
56	TR3,5-9	3-10008	Transistor, NPN, PWR	04713	2N3055	6					
57	TR4,10-14	3-10009	Transistor, PNP, PWR	04713	2N6246	6					
58											
59	D12,14	3-20011	Diode, Rect.	04713	1N1183A	2					
60	D13,15	3-20012	Diode, Rect.	04713	1N1183RA	2					
61											
62	XSW1-6	5-10073	Buttons, Black	Centralab	B304-BLK	6					
63											
64											
65											
66											
67											

NOTES:

Valhalla Scientific Inc.

PARTS LIST

MODEL: 2500E | DWG NO: 2500-603 | REV: C

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	I	N	I	N		REMARKS
68		4-10049	HEATSINK	53504	2500-206B	2					
69		4-10065	HEATSINK BRACKET	53504	2500-211A	2					
70											
71											
72	XTR1,XTR2	5-10207	HEATSINK, TO-5		209 CB	2					
73		5-10059	FAN,115VAC,50-60Hz	ROTRON	MU2A1	1					
74		5-10233	HEATSINK INSULATOR	53504	2500-212 A	1					
75			SCREW,PHIL,PAN,STAIN	81349	6-32 x 3/4	32					
76			SCREW,PHIL,PAN,STAIN	81349	6-32 x 1/2	10					
77			WASHER, SPLIT LOCK	81349	#6	18					
78			WASHER, FLAT	81349	#6	23					
79			NUT, RADIO HEX	81349	6-32	18					
80		5-10005	STANDOFF, 3/16"	88249	1530B-3/16	12					
81			WIRE BUS 18"	81349	22 AWG	1					
82			CLEAR SLEEVEING 12"	81349	22 AWG	1					
83											
84											

NOTES:

Federal Supply Codes for Manufacturers

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

00853
Sangamo Electric Company
Pickens, South Carolina

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01255
Litton Industries, Inc.
Beverly Hills, California

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Dallas, Texas

01686
RCL Electronics Inc.
Manchester, New Hampshire

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Westwood, Maine

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Syracuse, New York

03797
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03911
Clairex Corp.
Mt. Vernon, New York

04009
Arrow Hart Inc.
Hartford, Connecticut

04217
Essex International Inc.
Anaheim, California

04222
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04713
Motorola Inc.
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05276
Pomona Electronics Co., Inc.
Pomona, California

05277
Westinghouse Electric Corp.
Youngwood, Pennsylvania

05397
Kemet, Union Carbide Corp.
New York, New York

05574
Viking Industries
Chatsworth, California

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Columbia, South Carolina

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06743
Clevite Corp.
Cleveland, Ohio

07088
Kelvin Electric Company
Van Nuys, California

07256
Silicon Transistor Corp.
Chelmsford, Massachusetts

07263
Fairchild Semiconductor
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Rochester, New York

07716
I R C Incorporated
Burlington, Iowa

07910
Teledyne Semiconductor
Hawthorne, California

08065
Accurate Rubber and Plastics Co.
San Diego, California

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Cleveland, Ohio

09026
Babcock Electronics Corp.
Costa Mesa, California

09214
G. E. Co. Semi-Conductor
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

11236
CTS of Berne
Berne, Indiana

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Hicksville, New York

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12405
Hysol Corporation
El Monte, California

12406
Elpac, Incorporated
Fullerton, California

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13454
Texas Crystals
River Grove, Illinois

13511
Amphenol Cadre Div.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Concord, New Hampshire

14099
Semtech Corp.
Newbury Park, California

14655
Cornell-Dublier Electronics
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14936
General Instrument Corp.
Hicksville, New York

15801
Fenwal Electronics Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors
Mountain View, California

15849
Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Cambridge, Maryland

16758
Delco Electronics
Kokomo, Indiana

17856
Siliconix, Inc.
Santa Clara, California

18324
Signetics Corp.
Sunnyvale, California

Federal Supply Codes for Manufacturers (cont.)

18612
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18722
R C A
Mountaintop, Pennsylvania

18927
GTE Sylvania Inc.
Titusville, Pennsylvania

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23936
Pamotor Div.
Burlingham, California

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Slatersville, Rhode Island

25684
Victoreen Instrument Co., Inc.
Oak Lawn, Illinois

27014
National Semiconductor Corp.
Santa Clara, California

27556
IMB Electronic Products
Santa Fe Springs, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota

28480
Hewlett Packard Co.
Palo Alto, California

29083
Monsanto Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

30983
Electra/Midland
San Diego, California

32539
Mura Corp.
Great Neck, New York

32897
Erie Technological Products, Inc.
Carlisle, Pennsylvania

32997
Bourns Inc.
Riverside, California

33173
General Electric Co.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

43543
Nytronics Inc.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

53504
Valhalla Scientific, Inc.
San Diego, California

54294
Cutler-Hammer Inc.
Selma, North Carolina

55026
Simpson Electric Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

65092
Weston Instruments Inc.
Newark, New Jersey

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71279
Cambridge Thermionic Corp.
Cambridge, Massachusetts

71400
Bussmann Mfg.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Brooklyn, New York

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73445
Amperex Electronic Corp.
Hicksville, New York

73734
Federal Screw Products, Inc.
Chicago, Illinois

73899
JFD Electronics Co.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74276
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76055
Mallory Controls
Frankfort, Indiana

76493
J.W. Miller Company
Los Angeles, California

76854
Oak Industries Inc.
Crystal Lake, Illinois

77342
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp.
Cleveland, Ohio

80031
Electro-Midland Corp.
Mepco Div.
Norristown, New Jersey

56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

81073
Grayhill, Inc.
La Grange, Illinois

Federal Supply Codes for Manufacturers (cont.)

81095
Triad Transformer Corp.
Venice, California

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
International Rectifier Corp.
Los Angeles, California

81741
Chicago Lock Co.
Chicago, Illinois

82389
Switchcraft Inc.
Chicago, Illinois

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83298
Bendix Corp.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83594
Burroughs Corp.
Plainfield, New Jersey

83740
Union Carbide Corp.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Peabody, Massachusetts

86684
Radio Corp. of America
Harrison, New Jersey

88219
Gould Inc.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Fuquay-Varian, North Carolina

89730
G.E. Co.
Newark, New Jersey

90201
Mallory Capacitor Co.
Indianapolis, Indiana

56365
Square D Co.
Chicago, Illinois

90303
Mallory Battery Co.
Tarrytown, New York

91094
Essex International Inc.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Woburn, Massachusetts

94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95712
Bendix Corp.
Franklin, Indiana

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

98278
Malco A. Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98978
IERC
Burbank, California

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Landsdowne, Pennsylvania

99942
Centrelab Semiconductor
El Monte, California

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